Module 3 - Calibration

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering

Tennessee Technological University

Topic 1 - Standards and Units

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- Thought Experiment Continued
- Standards and Calibration
- Base Dimensions and Unit
- Hierarchy of Standards

Thought Experiment Continued

Thought Experiment: Look around the room and choose an object. It can be anything. Ask yourself the following questions.

- What is the **true** length of the object?
- What is the physical meaning of that number?
- What do the units relate to?

Image: T.Hill

Standards and Calibration

When a measurement system is calibrated, its indicated value is compared directly with a reference value. This reference value forms the basis of the comparison and is known as the standard. This standard may be based on the output from a piece of equipment, from an object having a well- defined physical attribute to be used as a comparison, or from a well-accepted technique known to produce a reliable value.

Text: Theory and Design of Mechanical Measurments, 5th Edition

Standards and Calibration

A dimension defines a physical variable that is used to describe some aspect of a physical system. A unit defines a quantitative measure of a dimension.

Text: Theory and Design of Mechanical Measurments, 5th Edition

Base Dimensions and Unit

The dimension of mass is defined by the kilogram. Originally, the unit of the kilogram was defined by the mass of one liter of water at room temperature. But today an equivalent yet more consistent definition defines the kilogram exactly as the mass of a particular platinum-iridium cylindrical bar that is maintained under very specific conditions at the International Bureau of Weights and Measures located in Sevres, France. This particular bar (consisting of 90% platinum and 10% iridium by mass) forms the primary standard for the kilogram. It remains today as the only basic unit still defined in terms of a material object.

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Base Dimensions and Unit

The base units relate directly to a standard (historically).

Unit	**SI**		**I-P**	
Length	meter	(m)	foot	(ft)
Mass	kilogram	(kg)	slug	$(?)$
Time	second	(s)	second	(sec)
Temperature	degrees	$(^\circ C, ^\circ K)$	degrees	$(^\circ F, ^\circ R)$
Current	ampere	(A)	ampere	(A)
Substance	mole	(mol)	mole	(mol)
Light Intensity	candela	(cd)	candela	(cd)

Base Dimensions and Unit

Common derived units are defined in terms of the the base units.

Unit	SI		I-P	
Force	newton	(N)	pound-force	(lb_f)
Voltage	meter	(m)	foot	(ft)
Resistance	ohm	(Ω)	ohm	(Ω)
Capacitance	farah	(F)	farah	(F)
Inductance	henry	(H)	henry	(H)
Energy	joule	(J)	foot-pound	$(ft - lb)$
Power	watt	(W)	foot-pound per second	$(ft - lb/sec)$

Hierarchy of Standards

The known value applied to a measurement system during calibration becomes the standard on which the calibration is based.

So how do we pick this standard, and how good is it?

... primary standards are impractical as standards for normal calibration use ... there exists a hierarchy of reference and secondary standards used to duplicate the primary standards.

Primary standard	—	Maintained as absolute unit standard
Transfer standard	—	Used to calibrate local standards
Local standard	—	Used to calibrate working standards
Working standard	—	Used to calibrate local instruments

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